https://ntrs.nasa.gov/search.jsp?R=20130014612 2019-08-29T15:53:04+00:00Z

Evolution to Space

Jacob Cohen, Ph.D.
Chief Scientist
NASA Ames Research Center

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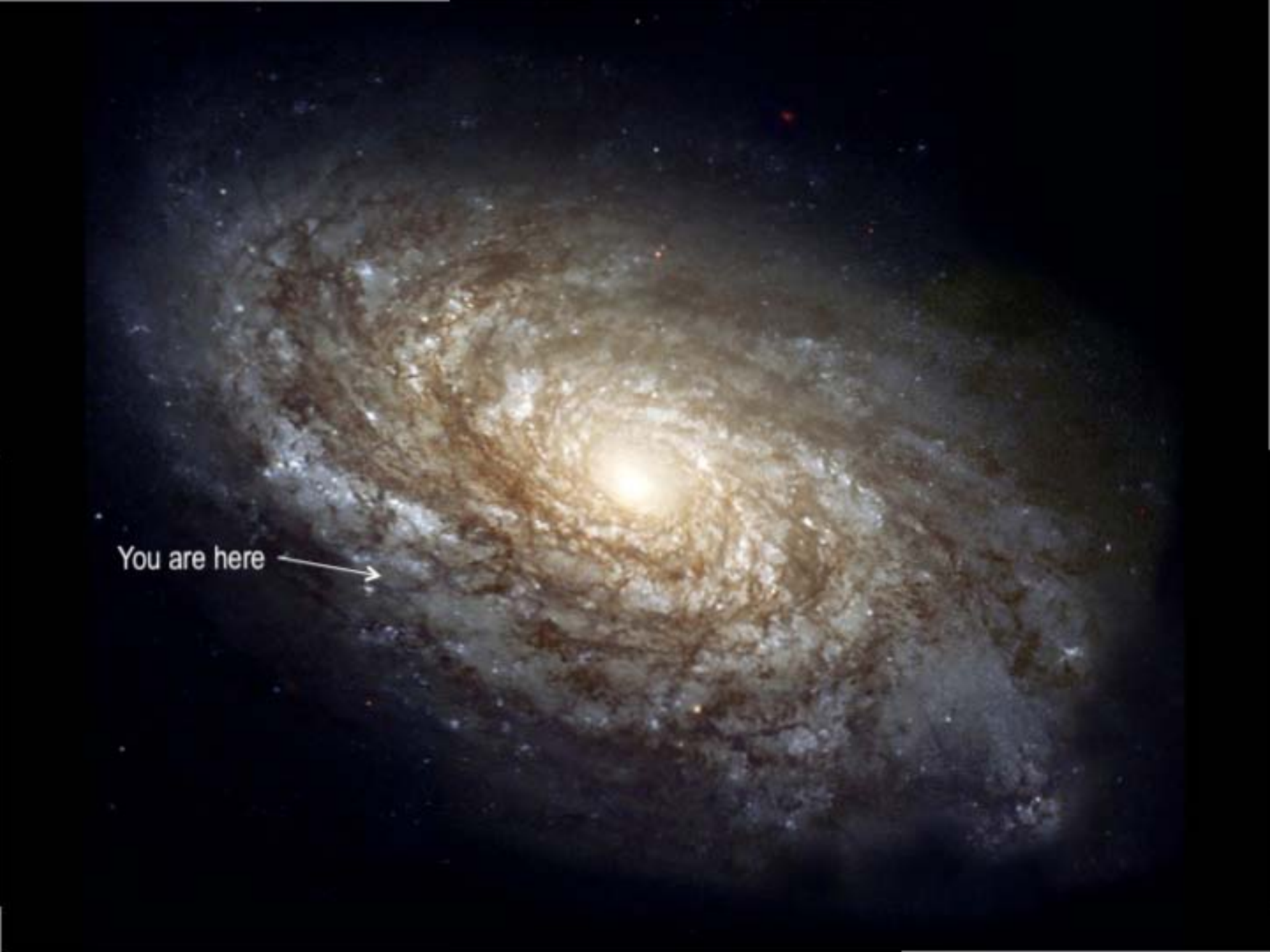
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Images Copyright Jacob Cohen, 2012

Disruptive Events Lead To New Opportunities

Standardization Speeds Up The Evolution Wheel

Inheritance, Variation and Selection

Image Copyright James Steidl, 2012; Used under license from Shutterstock.com

Standardization does not mean regulation.

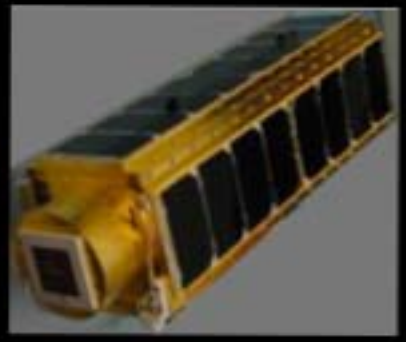
Standardization: The process of developing and implementing technical standards. The goals of standardization can be to help with independence of single suppliers (commoditization), compatibility, interoperability, safety, repeatability, or quality. (en.wikipedia.org)

Regulation: A principle, rule, or law designed to control or govern conduct. (thefreedictionary.com)

Modularization = Predictability of Standardization + Flexibility of Subcomponent Customization

IBM

Ford



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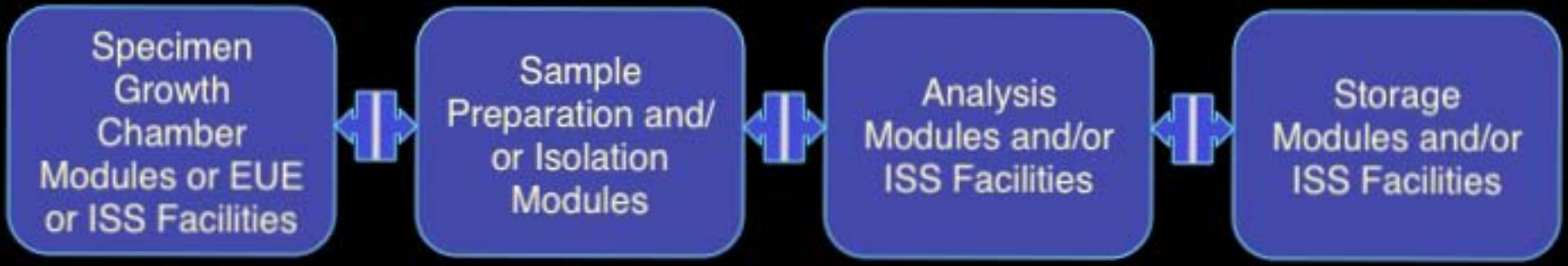
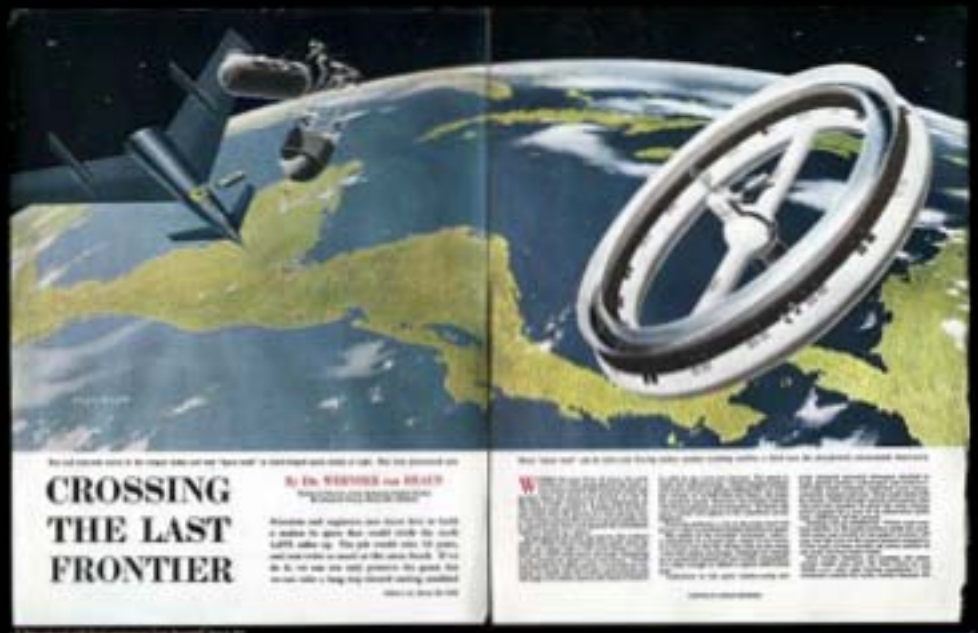
A method to maximize the science return from the ISS while reducing risk, schedule and ultimately cost per experimental unit.



Reference: WetLab 2, NanoLab and Cell Science hardware as proposed by J. Cohen

"Moon Landscape" by Petr Ginz (1942)



The March 22, 1952 issue of Collier's Magazine

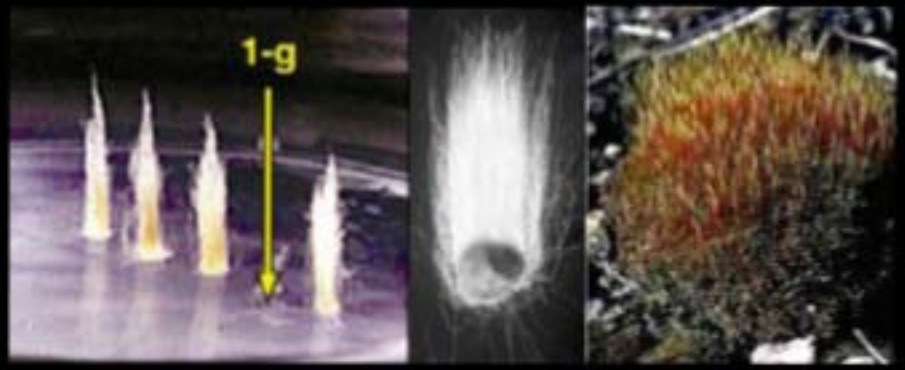
April 12, 1961
Gagarin first
human in space

Nov. 3, 1957
Laika, first
animal in space

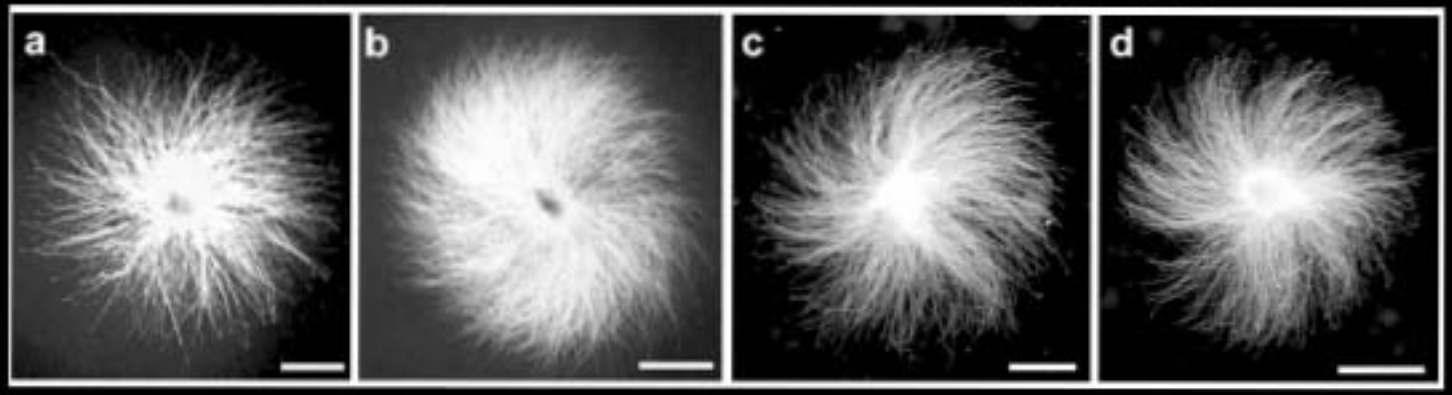
July 21, 1969
Armstrong and
Aldrin on the Moon

Microgravity and Moss Growth

On Earth



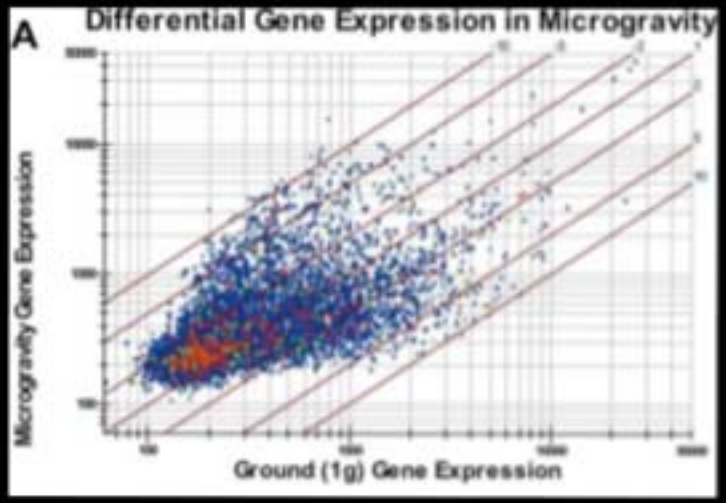
STS-87 STS-107

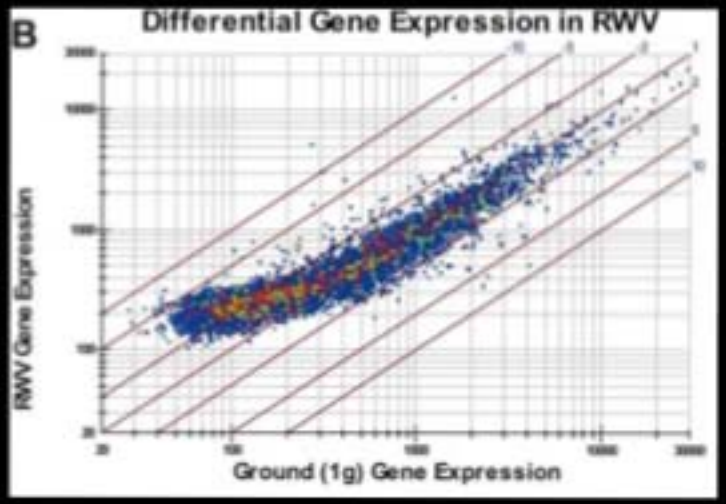


Gravitropic *Ceratodon purpureus* moss cells default to spiral growth in spaceflight microgravity.

Kern VD, Schwuchow JM, Reed DW, Nadeau JA, Lucas J, Skripnikov A, Sack FD.; Planta (2005) 221: 149–157

Microgravity and Gene Expression

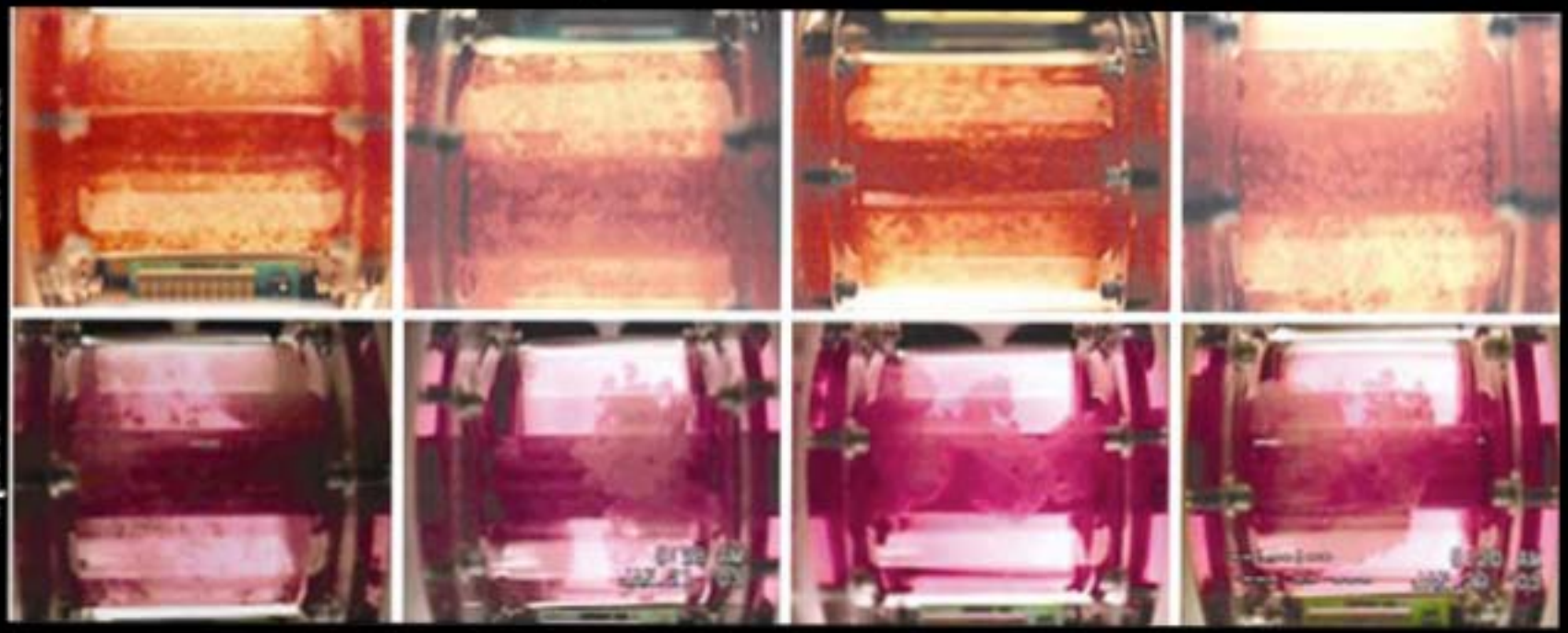




Gene array. Each cell culture condition including microgravity (A) and terrestrial rotating wall vessel (B) is compared with a static nonadherent bag culture. …. Sheer stress proteins and heat shock proteins are shown in green, and transcription factors are in red. …. More than 1,600 (1,632) change more than the specific threshold of threefold up and down in the flight (microgravity) culture (A) and more than 900 genes (914) changed in the terrestrial RWV culture (B); only a few genes (5) changed in a terrestrial centrifuge culture (not shown).

(Hammond, 2000)

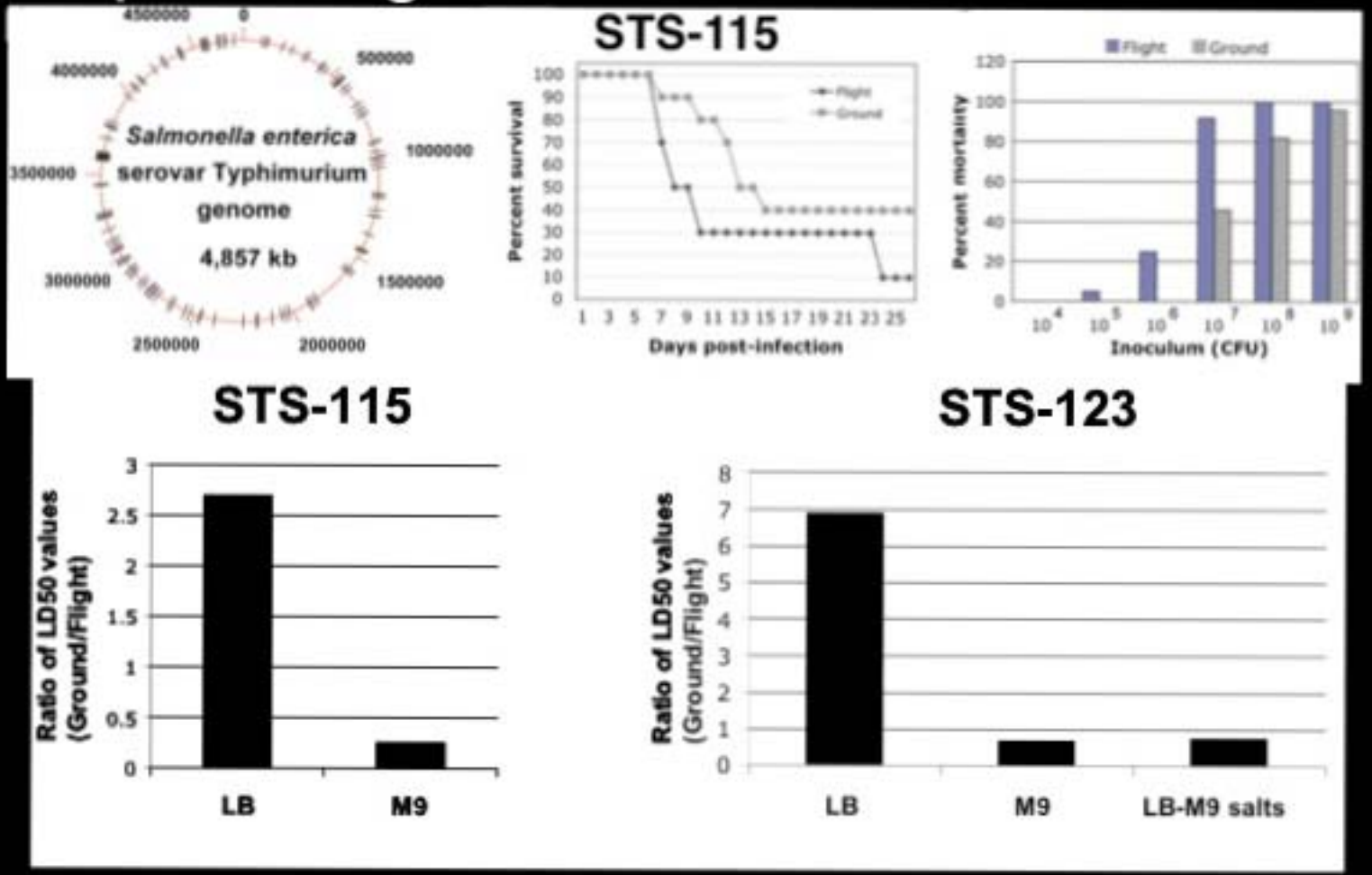
Microgravity and Tissue Culture



Formation of large prostate cancer organoids with the 3D rotating wall vessel bioreactor in space. Much larger prostate organoids were formed in space (30-50 cm across) as compared to the parallel ground study (3-5 cm) despite no difference in glucose utilization rate between ground and space studies.

(Wang, 2005)

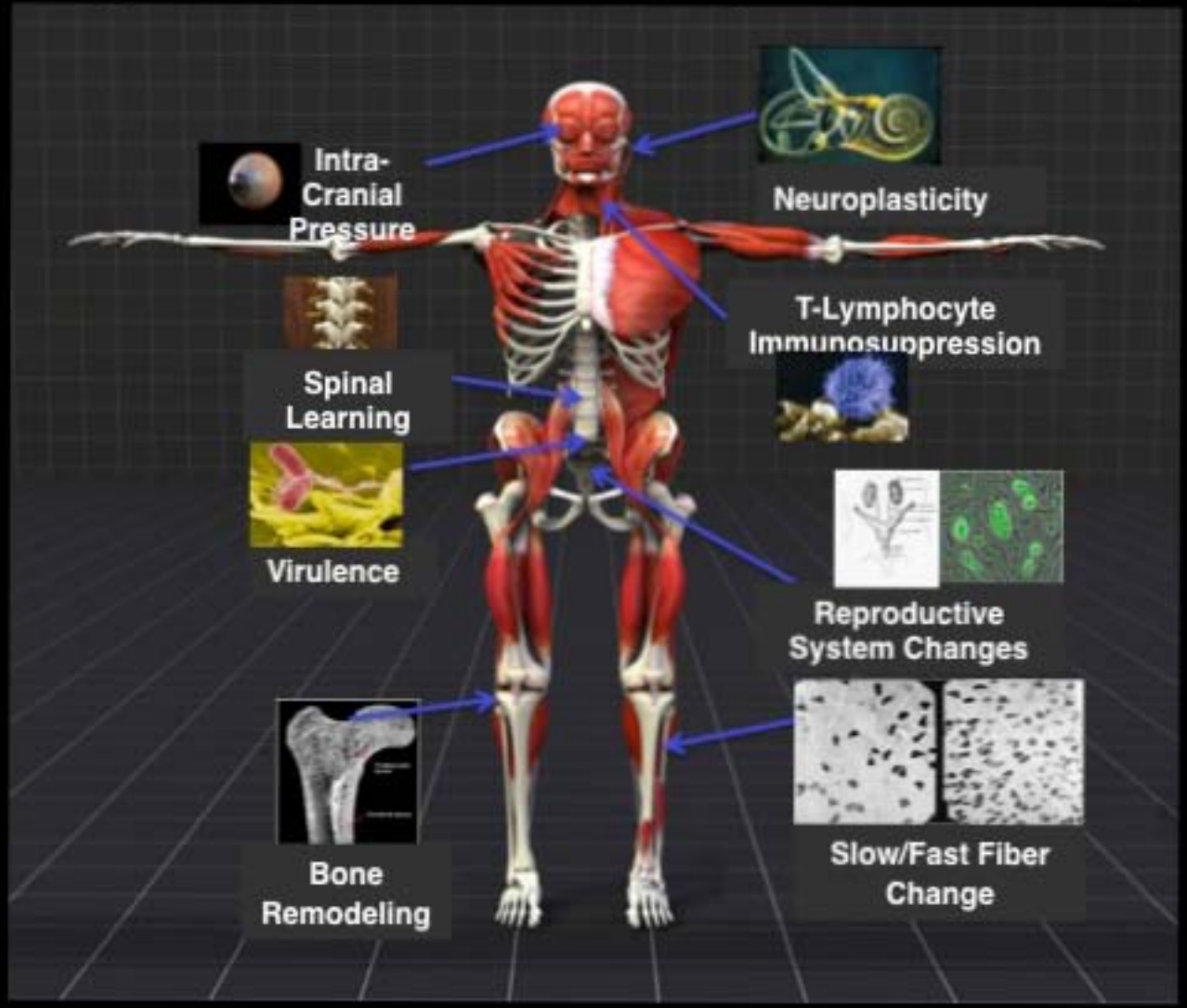
Space Flight and Microbial Virulence



Transient virulence increase of *S. typhimurium* in response to spaceflight in LB medium is not observed in M9 minimal medium or LB medium supplemented with M9 salts.

(Nickerson Lab; STS-115 and STS-123)

Examples of Human Responses to Space



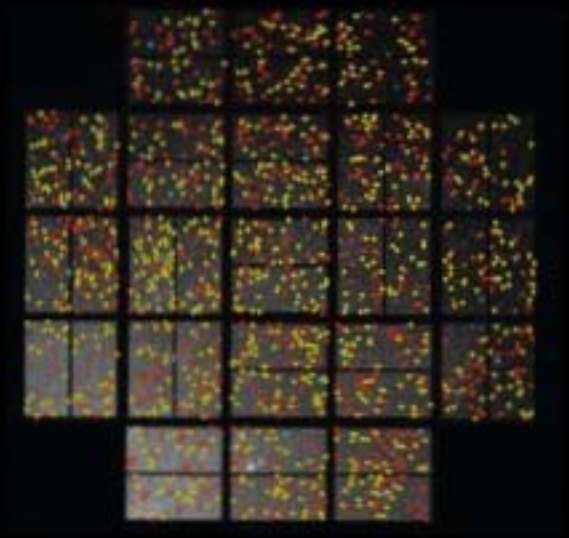
Not to Scale

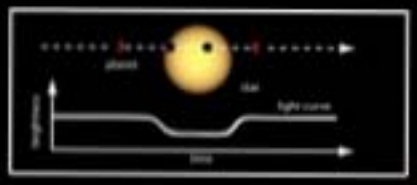
National Aeronautics and Space Administration

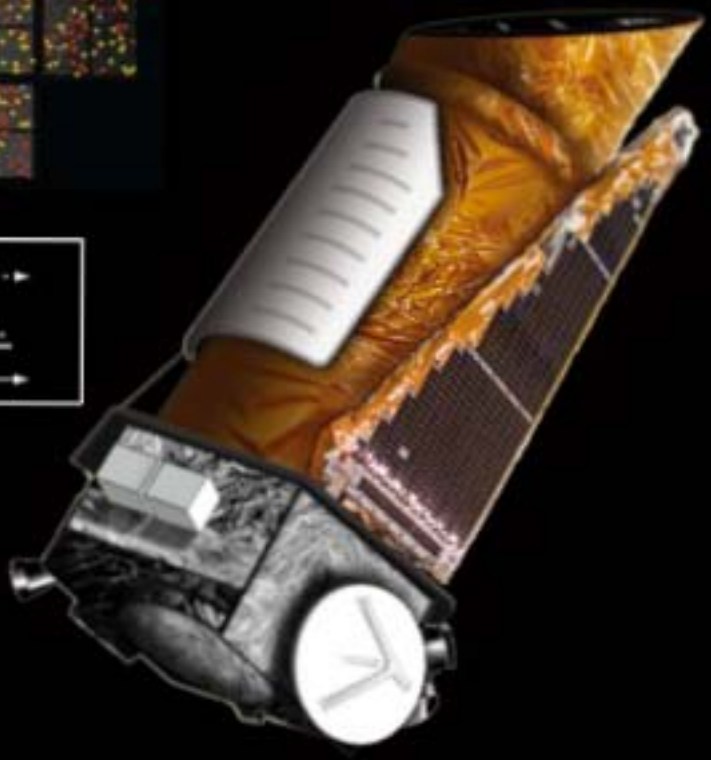
Ames

Discovery · Innovation · Solutions

Kepler





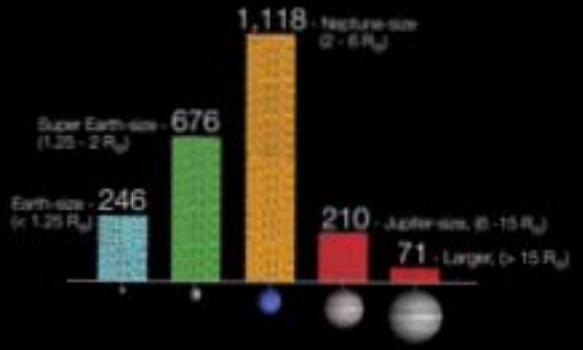


As of February 27, 2012

1,790 host stars

2,321 planet candidates

74 confirmed planets



Mass Breakdown Requirements
(Per Person-Day)

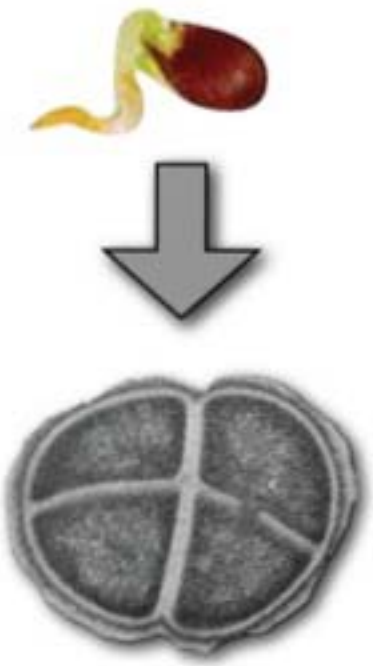
DAILY INPUTS - NOMINAL	kg
Oxygen	0.84
Food Solids	0.62
Water in Food	1.15
Food Prep Water	0.79
Drink	1.62
Hand/Face Wash Water	1.82
Shower Water	5.45
Clothes Wash Water	12.50
Dish Wash Water	5.45
Flush Water	0.50
TOTAL	30.74

Life Support

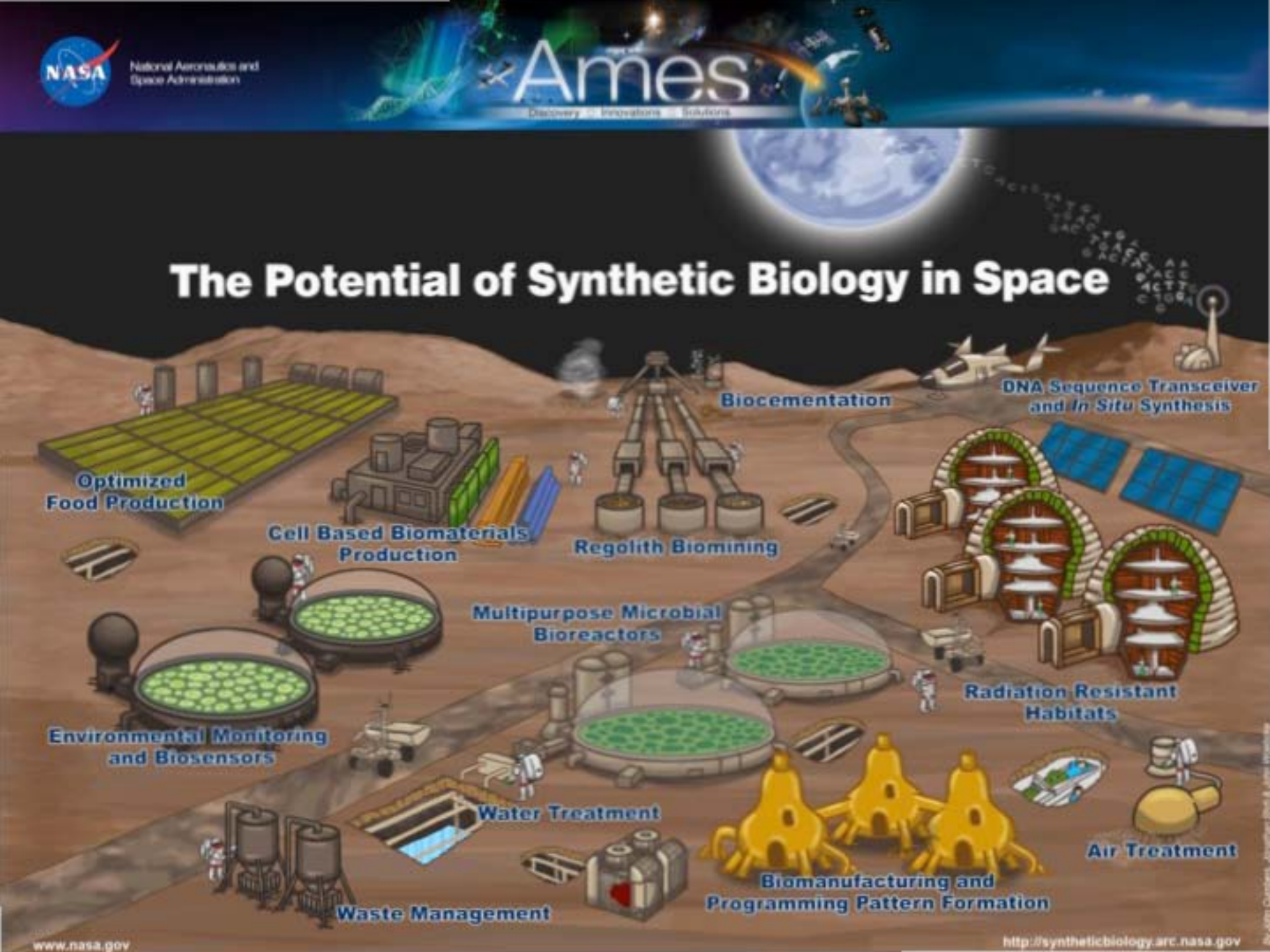
11.3 Metric Tons Per Person-Year

DAILY OUTPUTS - NOMINAL	kg
Carbon Dioxide	1.00
Respiration and Perspiration Water	2.28
Urine	1.50
Feces Water	0.09
Sweat Solids	0.02
Urine Solids	0.06
Feces Solids	0.03
Hygiene Water	6.68
Clothes Wash Water	11.90
Clothes Wash Latent Water	0.60
Other Latent Water	0.65
Dish Wash Water	5.43
Flush Water	0.50
TOTAL	30.74

Biology is the right tool for exploration



- Low mass
- Self replicating
- Fast growing
- Adaptable
- Flexible host
- A manufacturing technology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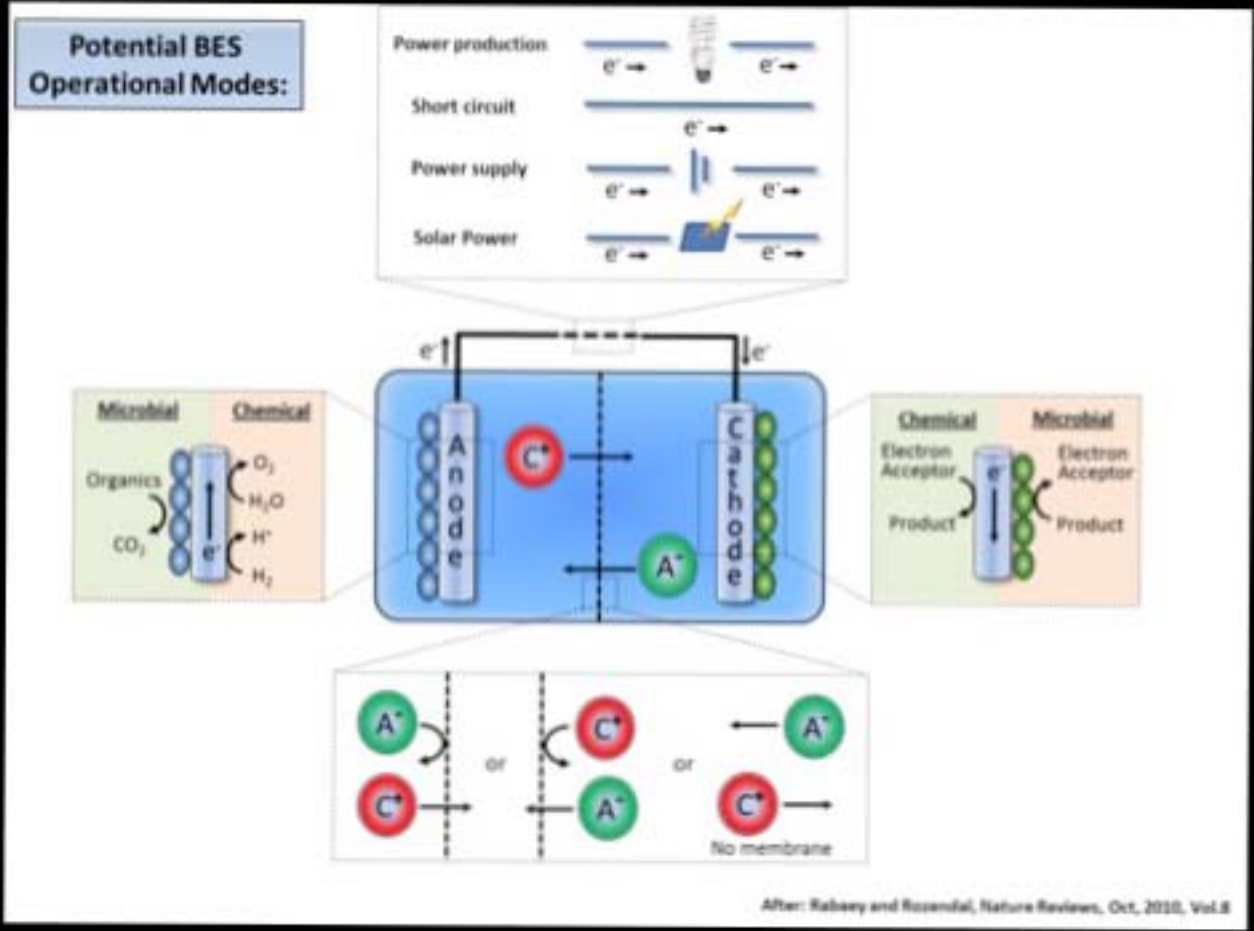
Ames
The Potential of Synthetic Biology in Space
Biocementation
DNA Sequence Transceiver and In Situ Synthesis
Optimized Food Production
Cell Based Biomaterials Production
Regolith Biomining
Multipurpose Microbial Bioreactors
Radiation Resistant Habitats
Environmental Monitoring and Biosensors
Water Treatment
Air Treatment
Biomanufacturing and Programming Pattern Formation
Waste Management
www.nasa.gov
http://syntheticbiology.arc.nasa.gov

Bioelectrochemical systems utilize microorganisms that are capable of generating electricity during the catalysis of substrates (microbial fuel cell - MFC) and/or utilizing electrical energy as the metabolic energy source for growth (reverse MFC).



Take it a step further: How about a synthetic biology ion engine?


The key to long term success in life is
imagination, persistence, and compassion
From the Past
From the Future
The Drive of Now
Working Together Humanity Will Conquer
The Exploration of the Time and Space Frontier
Thank You

NASA Ames Research Center

National Aeronautics and Space Administration

Ames

Discovery | Innovation | Solutions

Ames Today

- 2480 employees*
- ≈900M + annual revenue (including reimbursable)

*in addition, 900 students, summer 2012

- Science
  - Space, Earth, Biological Sciences
  - Astrobiology, Lunar Science
- Exploration Systems
  - Exploration Technology Development
  - Thermal Protection Systems
  - Supercomputing
- Projects and Missions
- Aeronautics & Aviation
  - NextGen Airspace Systems
  - Fundamental Aeronautics
  - Aviation Safety
  - Green Aviation
- Affordable Small Satellites
- Innovation, Education, & Entrepreneurial Collaborations
  - NASA Research Park

National Aeronautics and Space Administration

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Discovery | Innovations | Solutions

capabilities

Space Sciences
- Extrasolar Planets
- Infrared Astronomy
- Planetary Science
- Heliophysics/Data Analysis
- Lunar Science
- Astrobiology
- Astrochemistry
- Mars Climate Modeling Center

Earth Sciences
- Atmospheric Sciences
- Biospheric Sciences
- Climate Modeling
- Ecological Forecasting
- Airborne Science Campaigns
- Unmanned Aircraft Systems (UAS)

Biological Sciences
- Molecular & Cell Biology
- Synthetic Biology
- Gravitational Biology
- Radiation Measurement Technologies
- ISS Payloads

Biotechnology
- Biomedical Engineering
- Space Medicine
- Environmental and Life Support Systems
- Synthetic Biology

Intelligent Systems
- Robotics
- Computer Systems and Engineering
- Software Engineering
- Intelligent/Adaptive Systems

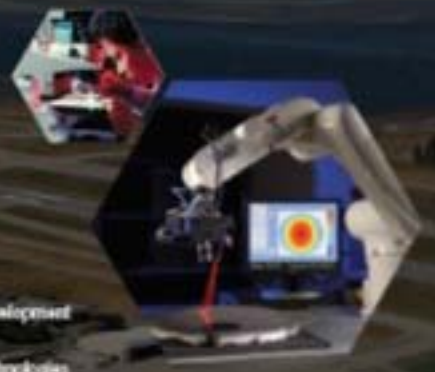
High Performance Computing
- Petaflop-Scale Systems Engineering
- Mass Data Storage
- Fundamental Modeling and Simulation
- Applied Modeling and Simulation
- Application Optimization
- Data Analysis and Visualization
- High-Performance Networks
- IT Security

Advanced Aerospace Materials and Devices
- Nanoscience
- Nanotechnology
- Bioengineering
- Computer Systems and Engineering
- Software Engineering
- Mathematical Modeling and Analysis
- Data Visualization

Space Transportation Technology/Thermal Protection Systems
- Chemistry/Chemical Engineering
- Advanced Materials and Processing Science
- Materials Engineering
- Thermal Systems
- Thermal Structures
- Aerothermodynamics
- Hyper-Thermal Testing
- System Architecture

Human Systems Integration
- Human-Machine Interaction
- Human Performance
- Integration and Training

Small Spacecraft
- Engineering Design
- Mission Operations
- Mission Design, Fabrication and Test



Airspace Systems
- Air Traffic Management Systems
- Fundamental Human Factors Research
- Human Factors Engineering
- Advanced Analysis and Design Method Development
- Crew Systems and Aviation Operations
- Advanced Experimentation and Testing Technologies

Applied Aerospace and Information Technology
- Sensors and Data Acquisition
- Avionics
- Control Systems, Guidance and Navigation
- Communication Networks and Engineering
- Computer Systems and Engineering
- Software Engineering
- Data Acquisition, Management and Storage
- Neural Networks and Systems
- Intelligent/Adaptive Systems
- Mathematical Modeling and Analysis
- Data Visualization
- Aerospace Systems Concept Development and Technology Assessment
- Advanced Analysis and Design Method Development
- Flight Dynamics
- Applied Aerodynamics
- Aeroelasticity
- Aerodynamics
- Thermal Systems
- Advanced Experimentation and Testing Technologies
- Simulation/Flight Research Systems
- Engineering Risk Assessment

capabilities

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Current Active Facilities, 2009

National Full Scale Aerodynamic Complex, 80x120 Wind Tunnel

Vertical Motion Simulator

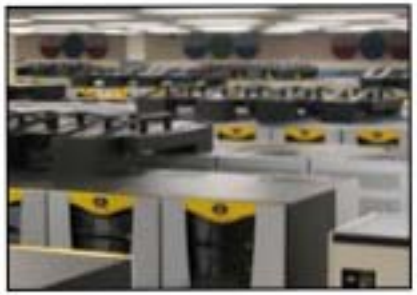
Small Spacecraft Development Facility

Unitary Plan Wind Tunnel

SOFIA

Machine Shops

Small Satellite Lab



Pleiades - Columbia Super Computer

Ballistic Range

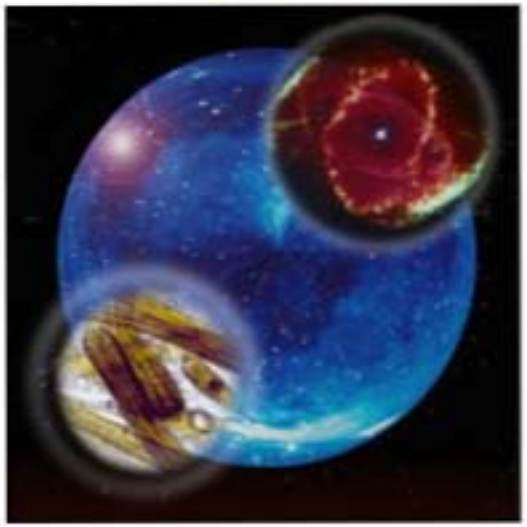
Arc Jets

Image copyright Dariusz Jezewski

Airfield and Hangars

Virtual Institutes at Ames

Astrobiology Institute



Scientific Study of life

NASA Lunar Science Institute

Advance the field of lunar science

NASA Aeronautics Research Institute

Creating new tools and technologies for reducing air traffic congestion and environmental impacts, improving safety, and designing aircraft

NASA Research Park

Innovative Collaboration in Science, Engineering & Education

90+ Partners Today

University Associates
Google-North East Section
University of California/UARC-Bldg. 555
M2MI Corporation-Bldg.19
Carnegie Mellon University-Bldg. 23
San Jose State University
-Metropolitan Technology
Center in Bldg. 583C
Foothill-De Anza Community College
United Negro College Fund Special
Programs Corporation-Bldg.19
Space Technology Center
-San Jose State, Stanford, Santa Clara Univ.,
Utah State Univ. /Micro Satellite Classes
Kentucky Science & Technology Corporation-Bldg.19
Bloom Energy-Bldg. 543 (Fuel Cell Research)
Industry Partners-Bldg. 566 & 19
UAV Center-Bldg.18
International Space University

WHY WE DO WHAT WE DO—PART ONE
FOUR THINGS NASA DOES

Number One: Improve Life on Earth

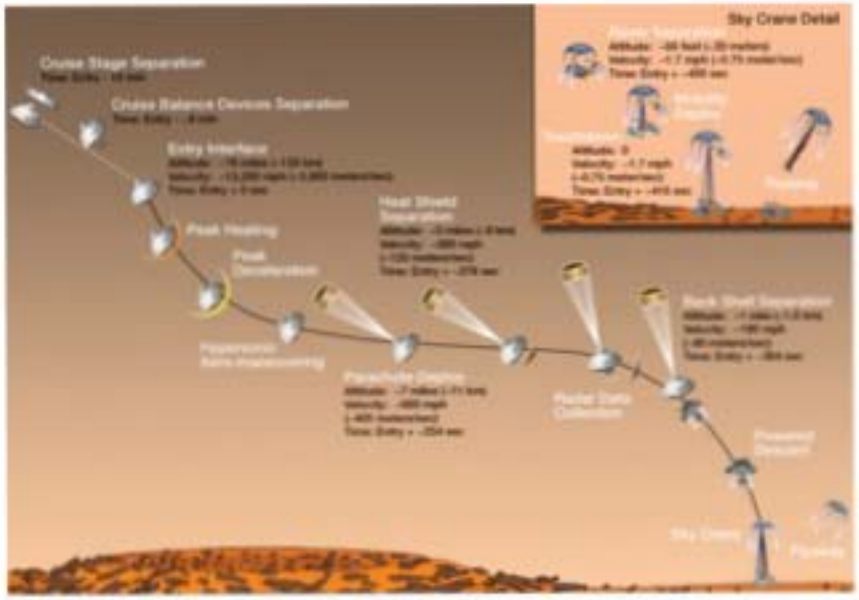
- **Aeronautics**
  - Next Gen
  - Environmentally Responsible Aviation
  - New Initiatives
    - **Autonomy, Electric Aviation**
- **Earth Climate studies**
    - **Site-specific Climate prediction**

Number Two: Conduct Earth and Space Science

- Astrophysics
  - **Origin/Distribution of Life in the Universe**
- Planetary science
  - **Moon**
  - **Mars**
  - **Asteroids**
- Earth Science
  - **Venture class**
- Heliospheric Physics
  - **IRIS**

Number Three: Human Space Exploration

- Fundamental Biology
- Entry, Descent & Landing
- Human Factors



Number Four : Cross Cutting Initiatives

- High end computing (quantum)
- Synthetic Biology
- Innovative Partnerships
  - **DoD**
  - **Industry**
  - **International /Academic**

Ames Contributions to Aeronautics

R. T. Jones

Flight Research

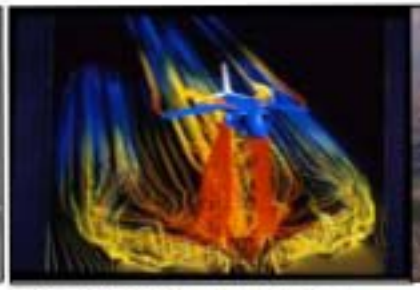
Cooper-Harper Rating Scale

Wind Tunnel Testing

Flight Simulation

Swept Wings

Conical Camber



Computational Fluid Dynamics

Short-Haul Aircraft

Takeoff Research

Air Traffic Management

Ames Contributions to Air Traffic Management

Dr. Heinz Erzberger

Traffic Management Advisor Build 1

Arrival Metering

Final Approach Spacing

Future Automated ATC

Products

Flight Management Systems

1970

1980

1990

2000

Optimal Guidance

Simulations

Intelligent Software

Human Factors

Field Test

Scheduling Algorithms

Benefits Analysis

Research Spectrum

Ames Contributions to Mercury and Gemini

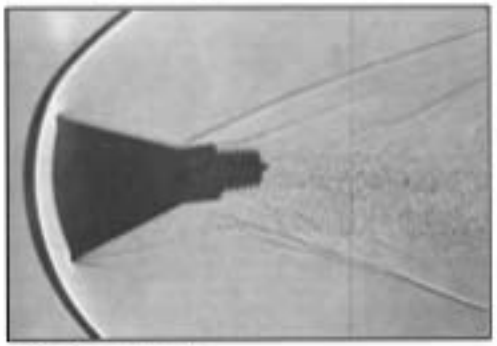
Blunt Body Re-entry

Free Flight Ablation Test
Arc Jet Facility

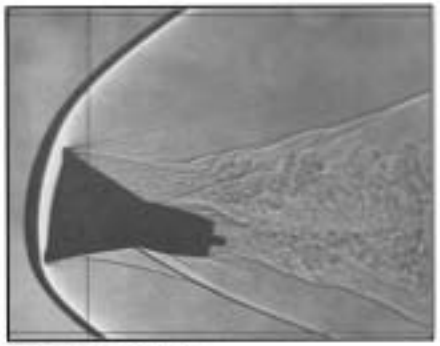
Re-entry Aerodynamics

Tektites and Trajectory Studies
Dean Chapman

Re-entry Airflow and Stability Pattern Studies
Hypervelocity Free-Flight Facility



Shadowgraph
Project Mercury Re-entry Capsule



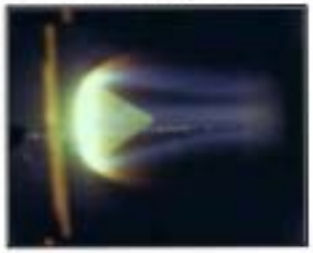
Shadowgraph
Project Gemini Re-entry Capsule

Spacecraft Testing and Evaluation
Unitary Plan Wind Tunnel

Ames Contributions to Apollo

H. Julian Allen
Ames Director
During Apollo
Program

Technology Research

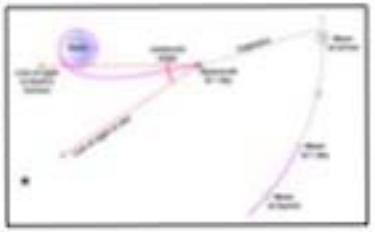


Free Flight Ablation
Test, Blunt Body
Re-entry Studies

Steerable
Parachute

Navigation
Simulator

Launch Escape
System
Unitary Plan WT



Guidance System

Lunar Surface
Magnetometer

Dr. Cyril
Ponnamperuma
Analyzing
Moon Sample

Moon Sample Analysis

Life Sciences Glove Boxes, Lunar Receiving Facility

National Aeronautics and Space Administration

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Ames Contributions to the Space Shuttle

Supporting Research

Lifting Bodies

Aerodynamics

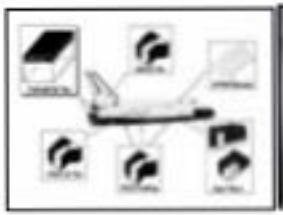
Orbiter/Boeing 747
Ferry Configuration
14-foot WT

Ascent Aerodynamics & Aerothermodynamics

Exhaust Plume
Interactions
9 x 7 WT

Shuttle Abort Maneuver
14-foot WT

Thermal Protection System



TPS Materials
Development

Stagnation
Point Tests
Arc Jet

Low-Speed Descent Aerodynamics

36 Percent Scale
Model 40 x 80 WT

Flight Simulation

Vertical Motion
Simulator

Entry Aerodynamics & Aerothermodynamics

Shadowgraph of
Bow Shock Wave
at Mach 7

CFD Simulation Results for the Shuttle Stack During Ascent

Simulation on Hyperwall

Return to Flight

Columbia Supercomputer,
Wind Tunnels,
Debris Transport,
Ascent Aerodynamics,
Thermal Protection Experts,
Thermal Analysis,
Structural Analysis,
Database management, and
Virtual Motion Simulator

Standby Support During Missions

Ames-Dryden Flight Research Center

Shuttle Landing Site (38 Landings between 1981-1994)

National Aeronautics and Space Administration

Ames

Discovery · Innovations · Solutions

Ames Contributions to Astrobiology

Investigation into:

-Context for habitable environments and life

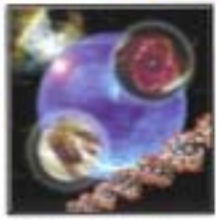
-Origins of life and its impact on the planetary environment

- Future of life in changing environments

*Excerpted from 2003-2004 NAI ARC team report

SETI

NPI



Astrobiology Institute

Exobiology Branch

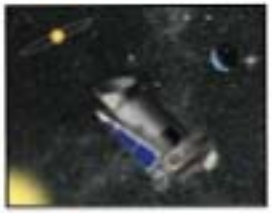
Dr. Harold P. Klein

Dr. Cyril Ponnamperuma

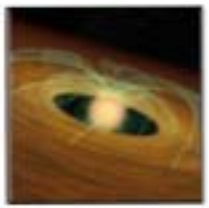
Dr. Baruch Blumberg

Dr. David Morrison

G. Scott Hubbard



Kepler



Spitzer Space Telescope

Airborne Science Platforms

Robots and Other Instruments

Orbiters and Probes

Earth, the Moon, Mars, and other planets

Stars

Meteors & Comets

Asteroids

National Aeronautics and Space Administration

Ames

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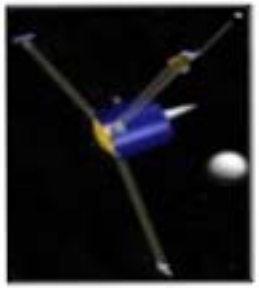
Ames Contributions to Lunar Exploration

Apollo
1969

Safe human landing on the Moon and return to Earth

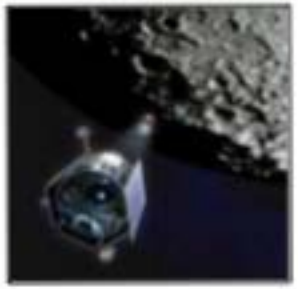
- Guidance System
- Lunar Surface Magnetometer
- Blunt Body Re-entry
- Moon Sample Analysis (Lunar Receiving Facility)
- Launch Escape System



Lunar Prospector
1998

Spectroscopic survey of entire lunar surface

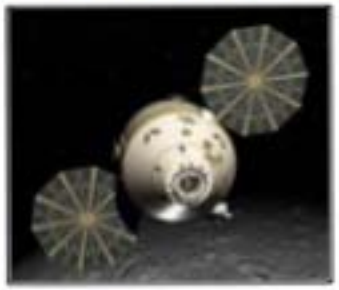
- Mission and Operations
- Managed Payload, Instruments, and Spacecraft Design and Development



LCROSS
2008

Confirm presence or absence of water or ice in a polar lunar crater

- Mission and Operations
- Managed Payload, Instruments, and Spacecraft Design and Development



Constellation

Human exploration of the Moon, Mars, and beyond

Orion CEV
- Thermal Protection System
- Aero/Aero-thermal Database
-Flight Software and Guidance, Navigation and Control

Mission Operations
- Flight Control Software
- Training Applications
- Planning and Development Tasks

Ares I
- Integrated Systems Health Mgmt.
- Launch Abort System Software and Instrumentation
- Aero/Aerothermal Models and Analysis and Risk Assessments

Technology and Science Support

Lunar Crater Observation

Exploration Life Support

Radiation Dosimetry and Medical Sensor Technology

Space Human Factors

ISS Exploration Experiments

Piloted Spacecraft Handling

Reentry

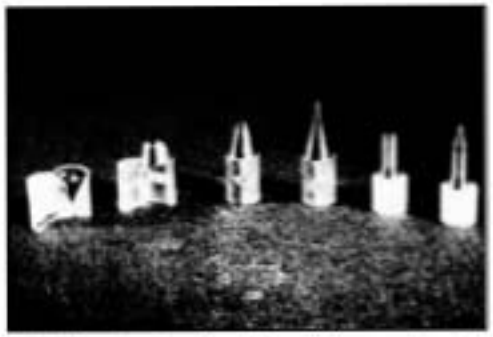
Palmer Dyal

Apollo Lunar Surface Magnetometer

NASA Lunar Science Institute
March 2008

Ames Contributions to Mars Exploration

Dr. Harold P. Klein



Early Tests for Mars/Venus Entry in Carbon Dioxide and Nitrogen Mixtures (Early 1960s)

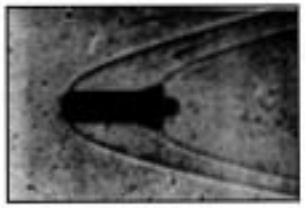
Biological Investigation (Viking)

Thermal Protection Systems (MER and MSL)

Science Operations (MER)

Mission Support Software (MER)

Landing Site Selection (MER)



Shadowgraphs showing the shock wave shape

Human-Centered Computing and Fatigue Countermeasures (MER)

Parachute Wind Tunnel Tests (MER and MSL)

Ames Contributions to MSL

Mars Science Laboratory Entry, Descent, and Landing Instrument (MEDLI)

Sophisticated plugs with multiple temperature sensors that measure atmospheric conditions and performance of the heat shield

PICA Heat Shield

Mars Science Laboratory InterfaCE (MSLICE)

Software tool to plan the science activities of the Mars rover and maximize scientific research

Parachute test

CheMin

National Aeronautics and Space Administration

Ames

Discovery · Innovation · Solutions

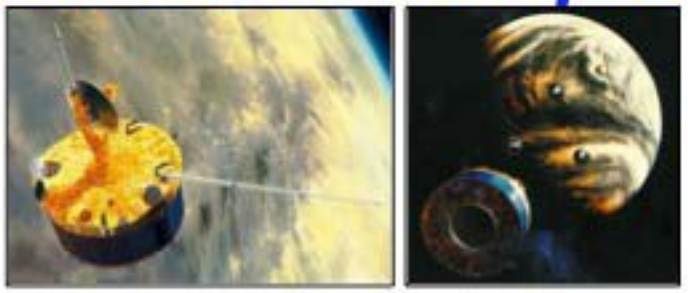
Ames Contributions to Small Spacecraft

Pioneer 6-9
1965-1968

Studied the solar wind from a solar orbit.

Pioneer 10 & 11
1972-1973

First man-made objects to safely pass the asteroid belt, provide detailed investigation of Jupiter and Saturn, and, leave our solar system.



Pioneer Venus
May 1978

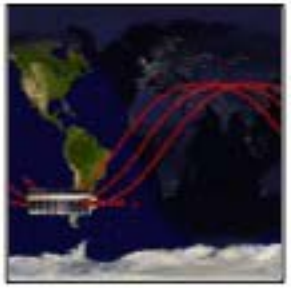
Completed radar mapping of 93% of the planet's surface. The four probes and bus gathered data about the Venusian atmosphere.

Lunar Prospector
1998

Carried out a spectroscopic survey of entire lunar surface.

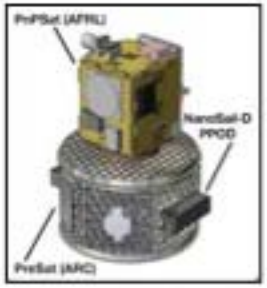
SOAREX
2004-

Conduct suborbital aerodynamic reentry experiments.



GeneSat
2006

Miniature satellite provided life support to E.Coli bacteria in orbit.



NanoSail-D/PreSat
2008

Demonstrate and validate performance of the platform.

PharmaSat
2008

Miniature satellite will carry yeast spores.

LCROSS
2008

Confirm presence or absence of water or ice in a polar lunar crater.

LADEE
2011

Assess the atmosphere and surface dust of Earth's moon.